REMARKS

The Official Action of 25 July 2008 has been carefully considered and reconsideration of the application as amended is respectfully requested.

The specification has been amended to make changes of an editorial and clerical nature. The amendments to the specification remove the basis for the Examiner's objection on page 2 of the Official Action.

Claim 1 is amended to further narrow the syngas number (SN) of the gaseous feedstock to be between 1.85 and 2.15. Basis for this amendment may be found in paragraph 11 page 1 of the specification as published under Publication Number US 2008/0027150.

Claim 1 is further amended to also include the feature that the DME synthesis stage tail gas fed to the Fischer-Tropsch reaction stage comprises hydrogen, carbon monoxide and carbon dioxide with a syngas number (SN) between about 1.85 and about 2.15. Basis for this amendment may be found in paragraph 35 on page 2 of the specification as published under Publication Number US 2008/0027150. .

Claims 1 to 10 are pending in this application.

Claims 1 to 10 stand rejected under 35 U.S.C. 103(a) as being obvious over Gersmann et al (GB 2 092 172) in view of Espinoza et al (US 6,653,357), Janda et al (WO 02/26676 A2) and Ullmann's Encycopedia of Industrial Chemistry, 6th edition, pages 651-660. Applicant respectfully but strongly disagrees with the Examiner on the nonobviousness of the subject matter of amended claim 1 and its dependent claims, for at least the reasons set out in the following paragraphs.

The Claimed Invention

Methanol synthesis and DME synthesis are equilibrium-limited and, as such, the per pass conversion of CO and H_2 and CO_2 is restricted, meaning that a standalone DME synthesis facility requires high recycle rates in order to achieve good overall conversion of the syngas. Syngas with a syngas number of between 1.85 and 2.15 is well-suited for use as a feed in a methanol and DME synthesis process, as such a syngas is stoichiometrically balanced for methanol and DME synthesis. Stoichiometrically balanced means that the reagents are present in proportions relative to each other close to their consumption rate in the synthesis. In addition, the syngas number is not affected by the water gas shift reaction. This implies that a stoichiometrically balanced feed also results in a stoichiometrically balanced tail gas. However, because of the equilibrium-limited nature of the synthesis, even with a stoichiometrically balanced syngas with a syngas number of between 1.85 and 2.15, high recycle rates are required to achieve high overall conversion of the syngas in a DME synthesis stage. The

use of a high recycle rate is however an expensive option and it may not always be desirable for a number of reasons.

The problem to be solved by the present invention can therefore be considered to be how to improve the overall yield of a syngas conversion process which includes a DME synthesis stage and which is fed a substantially stoichiometrically balanced feedstock, without employing a large recycle rate in the DME synthesis stage to achieve satisfactorily high conversion of the syngas.

The solution proposed by the present invention is to employ a non-equilibrium-limited Fischer-Tropsch hydrocarbon synthesis stage to convert unconverted syngas from the DME synthesis stage to valuable hydrocarbons. This limits the extent to which recycle is required in the DME synthesis stage as it is no longer required to achieve high overall conversion in the DME synthesis stage. For the DME synthesis stage, a ratio of tail gas recycle to gaseous feedstock can thus be between 0 : 1 and about 2 : 1, which is less than the recycle encountered in a conventional standalone process for the production of DME. In addition, the solution proposed by the present application is specific in claiming that the Fischer-Tropsch hydrocarbon synthesis stage is a two-phase high temperature catalytic Fischer-Tropsch synthesis stage. This leads to two particularly unexpected advantages not suggested by any of the prior art documents of record:

Firstly, CO_2 is reactive in a two-phase high temperature catalytic Fischer-

Tropsch synthesis stage. In the Fischer-Tropsch hydrocarbon synthesis stage, CO_2 is thus converted to valuable hydrocarbon product. This is important, as the unconverted synthesis gas from the DME synthesis stage will always contain some CO_2 due to the water gas shift activity of the catalyst typically employed in the DME synthesis stage. This water gas shift activity is further promoted in the DME synthesis stage as a result of the water that is formed in the DME synthesis stage when methanol is dehydrated.

Secondly, a syngas with a syngas number of between 1.85 and 2.15, which is ideally suitable and stoichiometrically balanced for use in a DME synthesis stage, is coincidentally also well-suited for use in a high temperature Fischer-Tropsch hydrocarbon synthesis stage. Bearing in mind that the syngas number is not affected by the water gas shift reaction, it will be appreciated that by starting with a syngas with a syngas number that is stoichiometrically balanced for DME synthesis (as is done in the present invention), the unconverted syngas from the DME synthesis stage will also have a syngas number which renders it still well-suited for use in a high temperature Fischer-Tropsch hydrocarbon synthesis stage. This is especially so when the overall conversion in the DME synthesis stage is restricted by limiting the recycle around the DME synthesis stage. This implies that no composition adjustment of the tail gas from the DME synthesis stage is required before the tail gas can be fed to the high temperature Fischer-Tropsch hydrocarbon synthesis stage. Claim 1 has been amended to include the feature that the DME synthesis stage tail gas fed to the Fischer-Tropsch reaction stage has a syngas number (SN) between about

1.85 and about 2.15. The present invention thus provides an elegant process for the high overall conversion of a stoichiometrically balanced syngas (i.e. a syngas with a syngas number between 1.85 and 2.15), producing valuable DME and hydrocarbons.

The Deficiencies of the Prior Art

The prior art documents of record, either alone or when taken in combination, do not teach or suggest the process of the invention.

Gersmann et al (GB 2 092 172 A) describe an improved process for the conversion of synthesis gas to oxygenates (methanol and dimethyl ether (DME) and paraffins). Gersmann et al state that syngas with an H_2/CO ratio of at least 0.5 can be converted to oxygen-containing organic compounds that are valuable in products or intermediate products. Gersmann et al recognise that conversion of synthesis gas to oxygenates is thermodynamically equilibrium-limited and that overall conversion can be improved by recycling unconverted H_2 and CO. The drawbacks to such an approach are listed as recycle being expensive and the build-up of CO_2 in the recycle loop. The build-up of CO_2 is explained by pointing out that catalysts used for the conversion of synthesis gas into oxygen-containing organic compounds generally have CO shift activity. This problem is further aggravated when the synthesised oxygenate is an ether, as the production of ethers is accompanied by the production of water which serves

as feedstock for further water gas shift. The problem that is solved by Gersmann et al is therefore how to achieve the preparation of oxygen-containing organic compounds by catalytic conversion of an H_2/CO mixture with a high conversion of the H_2/CO mixture into valuable organic compounds, without the necessity of recycling the unconverted H_2/CO mixture and removing the carbon dioxide (see page 1 lines 36-39). There is thus some similarity in the problems respectively addressed by the present invention and Gersmann et al, but the present invention proposes a more elegant and different solution.

The solution proposed by Gersmann et al is to contact the H_2 and CO present in the reaction product from the catalytic conversion of H_2 and CO to oxygen-containing organic compounds with a catalyst active for the conversion of H_2 and CO to paraffinic hydrocarbons, i.e. a Fischer-Tropsch hydrocarbon synthesis stage. Different systems may be used to effect the conversion to paraffins. Firstly, a mono-functional catalyst with an active metal component selected from cobalt, nickel and ruthenium may be used where the H_2/CO ratio in the feed gas to paraffin synthesis stage exceeds at least 1.5. The preferred range for the H_2/CO ratio is given as being between 1.75 and 2.25. Secondly, two solutions are proposed where the H_2/CO ratio of the feed gas to the paraffin synthesis stage is below 1.5. A bi-functional catalyst combination that also includes activity for water gas shift may be employed in the paraffin synthesis stage. In this embodiment, water is added to the feed gas to the paraffin synthesis stage. The bi-functional catalyst combination preferably consists of two separate catalysts, one catalyst being a paraffin synthesis catalyst with an

active component selected from cobalt, nickel and ruthenium, and the second catalyst being active for CO shift. In an alternative preferred embodiment, water is added to the feed gas to the oxygenate synthesis reactor to ensure that the H_2/CO ratio of the feed gas to the paraffin synthesis reactor contains an H_2/CO ratio suitably above 1.5. This embodiment exploits the water gas shift activity of the oxygenate synthesis catalyst to increase the H_2/CO ratio of the unconverted reactants. Gersmann et al also recognise that the water gas shift activity of the oxygenate synthesis catalyst obviates the need for an external shift to upwardly adjust the H_2/CO ratio of syngas feeds.

The most preferred catalyst with activity for paraffin synthesis in all of the embodiments disclosed by Gersmann et al is cobalt (see page 3 lines 15-20). The temperatures in the paraffin synthesis reactor are given as ranging from 125 °C to 300 °C, preferably between 175 °C and 275 °C (see page 3 lines 30-32).

The Examiner correctly points out that the syngas number is a useful parameter to characterise the syngas used in methanol and DME synthesis and that typical suitable values range from 1.8 to 2.2, as is mentioned by Janda et al (WO 02/26676). Gersmann et al, however, in no way refer to the syngas number and do not recognise that syngas with a syngas number between 1.85 and 2.15 is also highly suited for feeding to a high temperature Fischer-Tropsch reaction stage. Gersmann et al focus solely on the H_2/CO ratio and do not consider the syngas number at all. Gersmann et al thus also do not

recognise that when syngas with a less than balanced syngas number is used as the feedstock for a methanol and DME synthesis stage, the syngas number of the unconverted syngas will be even less balanced and will proceed to become even lower as the conversion in the methanol and DME synthesis stage is increased, rendering the unconverted syngas less suitable for use in a high temperature Fischer-Tropsch reaction stage. Gersmann et al thus do not recognise the importance of starting with a syngas with a syngas number between 1.85 and 2.15, limiting the syngas conversion in the DME synthesis stage to render a tail gas with a syngas number which is still approximately between 1.85 and 2.15, and using the tail gas in a high temperature Fischer-Tropsch reaction stage in which CO_2 is reactive, as is discussed in more detail hereunder. This deficiency is also not rectified by any other prior art of record and in particular not by Espinoza et al, which do not refer to a syngas number at all and which thus do not teach a suitable syngas number for high temperature Fischer-Tropsch synthesis.

Feeding syngas with a less than balanced syngas number to a methanol and/or DME synthesis stage, will result in a build-up of CO and CO_2 in the synthesis loop. This build-up of CO_2 is part of the problem solved by Gersmann et al. Considering that the range of preferred H_2/CO ratios in the fresh syngas to the DME synthesis stage includes numbers as low as 0.75 (0.75 H_2/CO ratio and with no CO_2) and that a substantial build-up of CO_2 can be expected in the DME synthesis stage, it will be appreciated that the syngas number of the unconverted syngas from the DME synthesis stage will be even

lower, e.g. less than 0.75. This is confirmed by the examples provided by Gersmann et al that deal with combined DME and Fischer-Tropsch synthesis (see Table D Experiments 5-7) which all provide an unconverted syngas stream from the DME synthesis stage with a syngas number of less than 1.25. It is thus apparent that Gersmann et al deal with a syngas with a less than balanced syngas number as the feed to the DME synthesis stage, resulting in a syngas with an even lower syngas number being used as a feed for the Fischer-Tropsch reaction stage. The teaching of Gersmann et al is thus in respect of a combined DME synthesis and Fischer-Tropsch hydrocarbon synthesis process using a syngas with a low syngas number, which is in direct contrast with the present invention which deals with a syngas having a substantially stoichiometrically balanced syngas number of between 1.85 and 2.15. The combination of the teachings of Gersmann et al and Espinoza et al does not rectify this, still remaining a teaching of a combined DME synthesis and Fischer-Tropsch hydrocarbon synthesis process using a syngas with a low syngas number, as Espinoza et al are entirely silent about syngas numbers.

The Fischer-Tropsch reaction stage contemplated by Gersmann et al is a low temperature Fischer-Tropsch reaction stage in which CO_2 will be an inert. Gersmann et al thus do not consider a process comprising a first reaction stage and a second reaction stage, with the second reaction stage being able to convert CO_2 to valuable product. Instead, in the process of Gersmann et al, the CO_2 is merely tolerated in the second reaction stage, thereby avoiding the necessity of removing the CO_2. This is in direct contrast to the present invention,

in which it is a central feature that the CO_2 from the DME synthesis stage is a reagent in the high temperature Fischer-Tropsch reaction stage, allowing an improvement in the overall conversion of carbon. As indicated in Table D of Gersmann et al, the total conversion of the H_2 and CO reaches a maximum in Experiment No. 3 of 94 %. This is in contrast to the overall H_2 and CO conversion of 96.7 % (see page 16) for a process in accordance with the present invention, which at least in part can be ascribed to conversion of CO_2 to valuable product. This difference is commercially significant.

In summary, Gersmann et al do not teach or suggest the process of the present invention, which starts with a syngas with a syngas number between 1.85 and 2.15, which then converts the syngas in a DME synthesis stage using no or a limited recycle to restrict the syngas conversion in the DME synthesis stage producing a tail gas with a syngas number between 1.85 and 2.15 which makes it well-suited for use in a high temperature Fischer-Tropsch hydrocarbon synthesis stage, and which then converts the tail gas in a high temperature Fischer-Tropsch hydrocarbon synthesis stage in which CO_2 is reactive.

The Applicant is in agreement with the Examiner that Espinoza et al (US 6,653,357 B1) teach a high temperature two-phase Fischer-Tropsch reaction. Espinoza et al are concerned with a method for controlling the selectivity profile in such a high temperature two-phase Fischer-Tropsch reaction by directly injecting a catalyst promoter into the reaction medium. The aim is to

improve the selectivity profile to olefins in the $C_2 - C_4$ range. Espinoza et al are however focussed on the details of high temperature two-phase Fischer-Tropsch synthesis as such and are completely silent as to employing high temperature two-phase Fischer-Tropsch synthesis together with DME synthesis and certainly in no way contemplates or suggests the invention as claimed by the present application. Espinoza et al are silent about syngas numbers and thus do not rectify the deficiency of Gersmann et al, as shown hereinbefore.

Insufficiency of *Prima Facie* Case

A person wishing to find a solution to the problem addressed by the present invention will find no guidance from Gersmann et al. To some extent Gersmann et al address different problems than the present invention and do not even hint at the solution provided by the present invention. Gersmann et al also teach away from the present invention e.g. in respect of the use of a low temperature Fischer-Tropsch reaction stage as compared to a high temperature Fischer-Tropsch reaction stage as a second reaction stage, and by using a low syngas number as compared to a balanced syngas number of between 1.85 and 2.15. "When the prior art teaches away from combining certain known elements, discovery of successful means of combining them is more likely to be nonobvious." *KSR*, 82 USPQ2d at 1395. In view of the above, there is thus no reason for a person wishing to find a solution to the problem addressed by the present invention, to turn to Gersmann et al for inspiration. If coming across the teaching of Gersmann et al by chance, a person will find an alternative but less

elegant solution to the solution provided by the present invention but will find no teaching or suggestion in this document that would steer such a person towards the present invention. Bearing in mind that Gersmann et al do not at all consider stoichiometrically balanced feedstocks (i.e. feedstocks having syngas numbers between 1.85 and 2.15), said person would also not view the teachings of Gersmann et al as particularly relevant to the problem facing said person.

It is well settled that "the Examiner bears the initial burden of factually supporting any *prima facie* case of obviousness. If the Examiner does not produce a *prima facie* case, the Applicant is under no obligation to submit evidence of non-obviousness." MPEP § 2142. It appears that the Examiners rejection of claims 1 to 10 relies on the argument that subject matter is obvious when it is based on a combination of prior art elements according to known methods to produce predictable results. To establish such a *prima facie* case of obviousness, the Examiner must show (1) a finding that the prior art included each element claimed, although not necessarily in a single prior art reference, with the only difference between the claimed invention and the prior art being the lack of actual combination of the elements in a single prior art reference; (2) a finding that one of ordinary skill in the art could have combined the elements as claimed by known methods, and that in combination, each element merely performs the same function as it does separately; (3) a finding that one of ordinary skill in the art would have recognized that the results of the combination were predictable; and (4) whatever additional findings based on the *Graham* factual inquiries may be necessary, in view of the facts of the case under consideration, to explain a

conclusion of obviousness.

With respect to the motivation to combine the references, the MPEP states “that combining known prior art elements is not sufficient to render the claimed invention obvious if the results would not have been predictable to one of ordinary skill in the art.” Furthermore, “A statement that modifications of the prior art to meet the claimed invention would have been "'well within the ordinary skill of the art at the time the claimed invention was made'" because the references relied upon teach that all aspects of the claimed invention were individually known in the art is not sufficient to establish a *prima facie* case of obviousness without some objective reason to combine the teachings of the references. *Ex parte Levengood*, 28 USPQ2d 1300 (Bd. Pat. App. & Inter. 1993). **'">[R]ejections on obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.'" *KSR*, USPQ2d at 1396 quoting *In re Kahn*, 441 F.3d 977, 988, 78 USPQ2d 1329, 1336 (Fed. Cir. 2006).< “ (MPEP2143.01).

It is respectfully submitted that, as Espinoza et al do not provide any teaching regarding syngas numbers for high temperature Fischer-Tropsch synthesis, at least the first element mentioned above is not present. Although, according to the MPEP, this does not necessarily mean that the claimed invention is nonobvious, the Examiner must explain why the difference(s) between the prior art and the claimed invention would have been obvious to one of ordinary skill in the art.

This has not been done. Furthermore, the Examiner has not provided reasoning to combine the teachings of the prior art references of record, in particular the teachings of Gersmann et al and Espinoza et al. It is also respectfully submitted that in the case in suit the increased overall H_2 and CO conversion, for example, would not have been predictable to one of ordinary skill in the art.

It is further respectfully submitted that there is no teaching in the prior art of record that would incentivise a skilled person to combine disparate elements of the teachings of Gersmann et al, Janda et al and Espinoza et al to arrive at the present invention without exercising inventive skill. As mentioned above, the Examiner has also not shown that the combination of prior art references, in particular the teachings of Gersmann et al and Espinoza et al, would lead to results that would have been predictable to one of ordinary skill in the art. Although <u>some</u> elements of the present invention are separately discernible in the prior art of record, the combination of features claimed in amended claim 1 can only be arrived at through the use of impermissible hindsight, or by exercising inventive skill. It is thus respectfully submitted that amended claim 1 is indeed inventive over the prior art of record.

<u>Conclusion</u>

The Applicant has submitted amendments and arguments that are believed clearly to show that the invention as claimed in claim 1 is patentably distinguishable over the prior art of record. All of the dependent claims 2 - 10 are

directly or indirectly dependent from claim 1 and thus also patently distinguish over the prior art of record. Since all objections and rejections of record are believed to have been overcome, it is respectfully submitted that the application is in allowable form. An early Notice of Allowance is urgently solicited and believed to be fully warranted.

Respectfully submitted,

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